

## BxCyNz Nanotube Development and Characterization

Completed Technology Project (2012 - 2013)



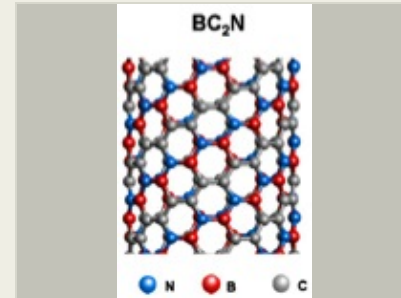
## Project Introduction

Boron Nitride Nanotubes (BNNTs) exhibit great promise for primary structure as well as thermal and radiation protection for future space exploration missions. They are structurally similar to Carbon Nanotubes (CNTs) and share extraordinary mechanical properties, but differ in chemical, optical, and electrical properties. Hybrid nanotubes constructed of B, C, and N elements are expected to form a new class of NTs with tunable properties between those of CNTs and BNNTs with increased applications.

BNNTs are produced by a new, high temperature pressurized vapor/condensation (PVC) technique without catalysts, using only boron and nitrogen as reactants. BNNTs are electrical insulators with a reported bandgap of about 6.0eV regardless of the chirality. This project adapts the PVC synthesis method to generate and investigate nanotubes consisting of boron, carbon and nitrogen with a controlled composition ratio. It is envisioned that BxCyNz nanotubes with the same excellent properties will be produced (radiation resistance and high aspect ratio, crystallinity and service temperature) but with different electronic and optical properties as a function of B, C, and N composition. With the incorporation of carbon, a tailored bandgap is possible from insulating/semiconducting (6.0eV) to metallic (0eV). Systematic modifications to the current apparatus will be applied to introduce carbon into the reaction zone where B and N precursors combine. In the new method, carbon can be added to the boron vapor through a number of methods. Various density ratios can be achieved with various buffer gases and the presence of oxygen may be useful in scavenging byproducts of the synthesis process. Carbon can be added to the boron vapor plume by modifying the target. Modeling will be used to modify the reaction chamber and parameters to produce optimized BCN nanotubes. High resolution transmission electron microscopy (HRTEM) can provide morphology assessment and the composition analysis by using electron diffraction, X-ray mapping, electron energy loss spectroscopy (EELS), and energy filtered TEM (EFTEM). EELS can provide a quantitative analysis of the composition. Photoluminescence spectroscopy can be employed to study the band gap of selected BxCyNz tubes in collaboration with the ONERA group. Thermogravimetric analysis (TGA) and TGA-Mass spectroscopy analysis can be correlated with the composition, defect, purity, and quality of the BxCyNz nanotube product.

## Anticipated Benefits

Photovoltaics and nanoelectronic devices provide reliable and affordable energy generation for space exploration with reduced weight and space environmental resistance benefits.



Project Image BxCyNz Nanotube Development and Characterization

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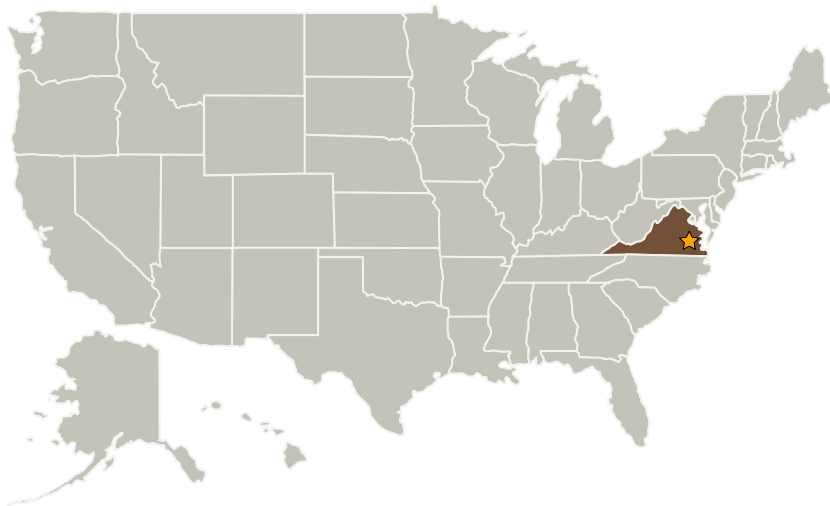
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## Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★ Langley Research Center (LaRC)	Lead Organization	NASA Center	Hampton, Virginia
National Institute of Aerospace	Supporting Organization	Academia	Hampton, Virginia

## Primary U.S. Work Locations

Virginia

## Organizational Responsibility

**Responsible Mission Directorate:**

Space Technology Mission Directorate (STMD)

**Lead Center / Facility:**

Langley Research Center (LaRC)

**Responsible Program:**

Center Innovation Fund: LaRC CIF

## Project Management

**Program Director:**

Michael R Lapointe

**Program Manager:**

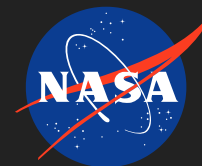
Julie A Williams-byrd

**Project Manager:**

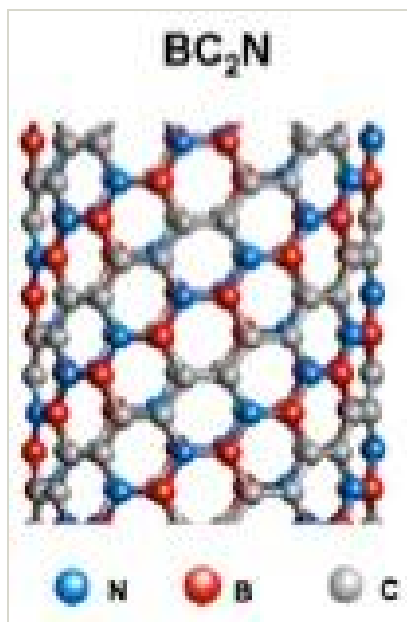
Jeffrey A Herath

**Principal Investigator:**

Catharine C Fay



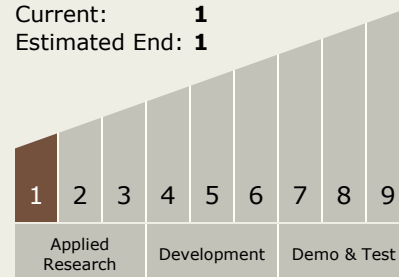
## Images

**26.jpg**

Project Image BxCyNz Nanotube Development and Characterization  
(<https://techport.nasa.gov/image/1256>)

## Technology Maturity (TRL)

Start: **1**  
Current: **1**  
Estimated End: **1**



## Technology Areas

**Primary:**

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - └ TX12.1 Materials
    - └ TX12.1.7 Special Materials